LANSCE
Los Alamos Neutron Science Center

Research Proposal for the use of Neutron Science Facilities

☐ **Fast Access** ☐ **Joint CINT Proposal**

Proposal Number: 20111560
Submission Number: S1565
Date Received: 03/14/11

Program Advisory Subcommittee: Defense-related Nuclear Science
Focus Area:

Flight Path/Instrument: 4FP60R / GEANIE
Estimated Beam Time (days): 30
Days Recommended: 0
Dates Desired: early in the run cycle (see propos
Impossible Dates:

TITLE
Delayed gamma-ray prodution from neutron-induced fission and search for ms isomers in the fission of 235U

☐ Continuation of Proposal #:

☐ Ph.D Thesis for:

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RESEARCH AREA

- ☐ Biological and Life Science
- ☐ Chemistry
- ☐ National Security
- ☐ Earth Sciences
- ☐ Engineering
- ☐ Environmental Sciences
- ☒ Nuc. Physics/chemistry
- ☐ Astrophysics
- ☐ Few Body Physics
- ☐ Fund. Physics
- ☐ Elec. Device Testing
- ☐ Dosimetry/Med/Bio
- ☐ Earth/Space Sciences
- ☐ Materials Properties/Test
- ☐ Other:
- ☐ Mat'l Science (incl Cond Matter)
- ☐ Medical Applications
- ☐ Nuclear Physics
- ☐ Polymers
- ☐ Physics (Excl Condensed Matter)
- ☐ Instrument Development
- ☒ Neutron Physics
- ☐ Fission
- ☐ Reactions
- ☒ Spectroscopy
- ☒ Nuc. Accel. Reactor Eng.
- ☒ Def. Science/Weapons Physics
- ☐ Radiography
- ☐ Threat Reduction/Homeland Sec.
- ☐ Other:

FUNDING AGENCY

- ☐ DOE/BES
- ☐ DOE/OBER
- ☒ DOE/NNSA
- ☐ DOE/NE
- ☐ DOE/SC
- ☐ DOE/Other
- ☐ DOD
- ☐ NSF
- ☐ Industry
- ☐ NASA
- ☐ NIH
- ☐ Foreign:
- ☐ Other US Gov't:
- ☐ Other:

PUBLICATIONS

Publications:

this field should not be mandatory

Abstract: S1565_Delayed_&#94.pdf

By electronic submission, the Principal Investigator certifies that this information is correct to the best of their knowledge.

Safety and Feasibility Review *(to be completed by LANSCE Instrument Scientist/Responsible)*

☐ **No further safety review required** ☐ **To be reviewed by Experiment Safety Committee**

☐ **Approved by Experiment Safety Committee, Date:**

Recommended # of days:	**Change PAC Subcommittee and/or Focus Area to:**	**Change Instrument to:**

Comments for PAC to consider:

Instrument scientist signature: **Date:**

Delayed γ-rays from neutron-induced fission: Search for millisecond isomers in ^{235}U fission fragments

There is considerable interest in the prompt and delayed γ-ray spectra following neutron-induced fission. The interest in delayed γ-ray spectra is two-fold: to improve the data libraries, and to implement active-interrogation schemes using neutrons and high-resolution γ-ray spectroscopy looking for specific delayed γ-rays. Proposed specific γ-rays are typically minutes later, but shorter times may be feasible and may be of interest. We propose to characterize the delayed γ-ray production following ^{235}U(n,f) in the time range from below 1ms to 100ms at GEANIE/WNR, and specifically to look for short-lived activity (isomers and isotopes) on this time scale. GEANIE has made use of the time structure of the WNR beam to identify sub-ms isomers in Tl nuclei [1], and this technique can be extended to longer times (see below). In addition, the spectroscopy of neutron-rich nuclei is an active area of research at radioactive-ion beam facilities, including the identification of isomers and characteristic γ-rays in the decay of neutron-rich nuclei. This experiment may be able to complement such activities.

Searches for delayed γ-rays following spontaneous fission[4,5] and fast fission[6,7] have been reported in the literature. While these studies often include information on the masses and elements from which the isomers arise, they generally only extend into half-life ranges as long as tens of μs. Longer-lived activities were historically been chemically separated, though on-line mass separation has greatly extended the time-range available, and has been used to measure half-lives below a second. The 18ms isomer in ^{117}Pd was observed using on-line mass separation[8]. Such techniques are still in active use[9], though searches for such activities through the fission-fragment region have not been reported. Online mass separation has not been applied extensively for heavier masses, presumably for technical reasons.

We propose to use the GEANIE array and the unique time structure of the LANSCE/WNR beam to look for and identify nuclear isomers among the fission fragments following ^{235}U(n,f). In order to maximize the statistics, we would run with a relatively large ^{235}U sample (we have 24g available, as laminated metal foils), and ignore the prompt γ-rays during the WNR macropulse.

In order to extend the time range of interest, we propose running the LANSCE accelerator at 30 Hz, with WNR at 9 or 10 Hz (20 Hz to Lujan, possibly 1 Hz north of the road – proton radiography or UCN). This will allow us to look for isomers from below 1ms to over 100ms.

Assuming a 1.5b fission cross section (average), $10e^6$ neutrons/s, and an effective mass of ^{235}U in the beam of 10g, we expect 38k fissions/s. For a weak 0.01% fission fragment yield, and, say, a 20% population of an isomer, we have about 0.7 isomers populated per second. With a 3% γ-ray efficiency, we get 80 events per hour. In order to assign an

unknown isomer to a nucleus, we will probably require a γγ coincidence (another factor of 3% in the rate calculation), which results in a 20 d run to get 1000 counts in a γγ coincidence. The actual run duration will depend on the WNR schedule – it is proposed to perform this run early in the run cycle, before the four beamlines involved in the new building construction are ready to run. Otherwise, the reduction in beam (from 40Hz to 10Hz) would not be feasible for such lengthy block of time.

[1] N Fotiades, RO Nelson, M Devlin, and JA Becker, Phys Rev **C77** 024306 (2008).
[2] D Rudolph, et al., Eur Phys J Special Topics **150** 173 (2007).
[3] F Naqvi, et al., Phys Rev **C82** 03423 (2010).
[4] W John, FW Guy, and JJ Weslowski, Phys Rev **2** 1451 (1970).
[5] C Gautherin, et al., Prog Part Nucl Phys **38** 289 (1997).
[6] JJ Ressler, et al., Phys Rev **C81** 014301 (2010).
[7] CM Folden III, et al., Phys Rev **C79** 064318 (2009).
[8] H Penttila, et al., Phys Scr **T32** 38 (1990).
[9] J Rissanen, et al., Phys Rev **C83** 011301 (2011).